# Positioning, Splinting, and Contracture Management

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**KEYWORDS**

• Splinting • Positioning • Contracture • Burn • Scar

The development of burn scar contracture is a pathologic condition. Burn scar contracture is defined as a loss of motion of a joint or anatomic structure as a result of normal skin being replaced by inextensible scar tissue.[1] The presence of a burn scar contracture has been shown to have a negative impact on a burn survivor's quality of life, particularly in regards to physical functioning.[2] A focus of burn rehabilitation should be to prevent or minimize contractures of the affected areas. Based on biomechanical considerations (discussed later), appropriate splinting and positioning is a critical component of any comprehensive burn rehabilitation program designed to attain optimal range-of-motion (ROM) outcomes. In 2008, a schema of burn rehabilitation phases (acute, intermediate, and long term) was developed to delineate the components of burn care treatment that are emphasized at different points in the continuum of care (**Fig. 1**).[3] **Table 1** describes the primary goals for positioning and splinting of burn patients during each burn rehabilitation phase.

## BIOMECHANICS

Biologic tissue adapts to the mechanical influences of applied external forces. Placing stress on tissue can cause it to change shape or form.[4] Excessive stress causes

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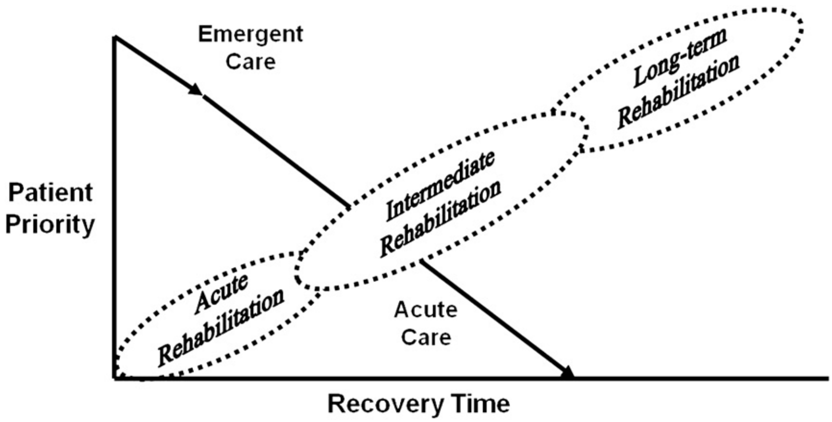


**Fig. 1.** Modified phases of burn rehabilitation.

damage to the tissue while too little stress is insufficient to stimulate change beyond normal cellular turnover. When treating patients with burn injury, splinting or positioning interventions must strike a stress balance to be effective. Developing an understanding of the biomechanic principles that underlie these physical interventions in the management of burn scar contracture aids in improving burn rehabilitation practice, leading to improved patient outcomes.

Both skin and scar tissue are comprised of an extracellular matrix—a solid fibrous network with a viscous liquid component, herein referred to as ground substance. In natural skin, collagen and elastic fibers provide integrity and elasticity, respectively. These components interact to protectively limit extensibility and provide tissue recoil after elongation. In contrast, burn scar tissue is only composed of collagen fibers within an altered ground substance environment and elastic fibers are absent. The collagen fibers are arranged in no predictable pattern. The predominant subcomponent of ground substance is chondroitin sulfate A, a substance found in abundance in bone tissue. This biologic composition of burn scar tissue is thought to be a possible cause of the inextensibility seen in burn scar.

With joint movement, skin or scar needs to accommodate to a change in limb length.[5,6] As limb length increases, collagen fibers unfurl and orient in the direction of force applied. As skin, more so than scar, is elongated further, additional collagen fibers sequentially align in the direction of the force applied. As collagen fibers move, the ground substance is displaced from between the fibrous network. When movement is reversed, the collagen fibers retract to their normal resting position while again having to redisplace the surrounding ground substance.

Successive length induction (SLI) or preconditioning of tissue, commonly referred to as stretching tissue, is an important concept to enlist whether fabricating a splint or setting up a positioning program for a patient. SLI entails repeatedly elongating a tissue

**Table 1**
**Positioning and splinting goals for each burn rehabilitation phase**

| Phase of Rehabilitation | Goal |
|---|---|
| Acute | Edema control and pressure relief |
| Intermediate | Tissue elongation and graft protection |
| Long term | Tissue elongation |

until it reaches its safe maximal length (**Fig. 2**). Maximal length of tissue has been reported to occur after 7 to 9 repetitions up to a tissue's yield point (**Fig. 3**).[7] In a clinical situation, however, the yield point of tissue is rarely reached due to pain complaints in conscious patients. Safe, maximal preconditioning of tissue can be clinically determined when a patient's ROM about a given joint ceases to increase with repeated repetitions. When preparing to fabricate or apply a splint, it is ideal to employ SLI until the tissue has achieved its maximal preconditioned length. At end range, this causes the tissue to be under tension. When tension is removed, tissue naturally retracts back to its desired resting length. Loading and unloading of tissue when plotted on a stress-strain curve produces a hysteresis type of pattern (see **Fig. 2**). With each successive lengthening, more and more ground substance is displaced from between the compacted fibers. The delay in tissue retraction is attributed to redistribution of the ground substance. It is important, however, to remember that all tissue wants to remain at its resting length. Much research is still needed in the area of biomechanics related to the burn injured population. Understanding basic biomechanical principles when applying rehabilitation techniques, however, helps burn therapists better understand the expected response to treatment.

Biomechanical principles can be applied when deciding on the appropriate positioning or splinting device to provide a lengthening force to a burn scar. If the device applies a static force, the biomechanical principle of stress relaxation is involved (**Fig. 4**). Before fabricating a splint, tissue surrounding the splinted joint of interest should be preconditioned to achieve an optimal length and the splint fabricated to maintain that length. The amount of tension felt by a patient decreases as the tissue accommodates to this extended length. Each time such force is applied (the static splint is donned), a patient's tissue may need to be preconditioned in order for the splint to fit properly again. Therefore, based on the principle of tissue stress relaxation, patients initially should be splinted or positioned with their tissue under tension knowing that the amount of tension will subside to a more comfortable level because the force over time required to maintain the tissue at a given length is reduced. Similarly, serial static and static progressive types of splints repeatedly harness stress relaxation of tissue or the principle of tissue creep (discussed later), depending on the interval of time between adjustments.

Tissue creep is another biomechanical principle used when splinting burn patients. Different from stress relaxation, tissue creep applies a constant force to progressively lengthen tissue over time (**Fig. 5**). This type of tissue reaction is seen with the use of dynamic splints. Dynamic splints commonly use elastic bands or springs to apply

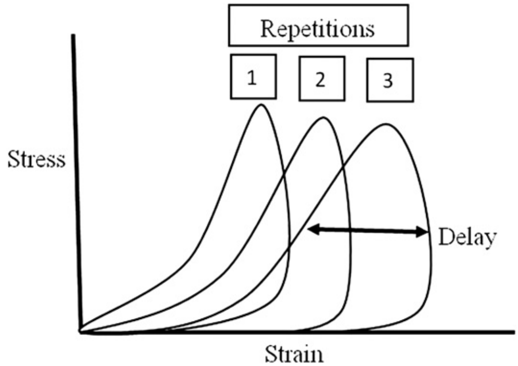


**Fig. 2.** Successive length induction and hysteresis.

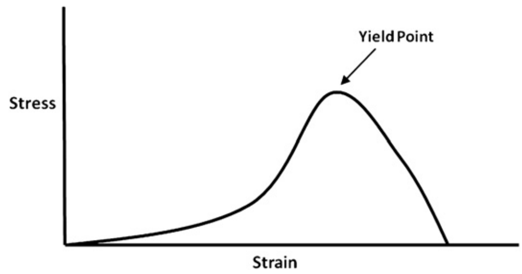


**Fig. 3.** Stress-strain curve.

constant tension to tissue. As tissue lengthens, the constant force causes the tissue to lengthen further by biologic adaptation through tissue growth. Tissue expanders used in burn reconstructive procedures are another example of the application of tissue creep.

## POSITIONING

The position of comfort after burn injury is typically the position that promotes deformity and therefore should be avoided. Suggested anticontracture positioning can be found in the literature.[8–10] Common anticontracture positioning has been described as follows: neck in extension, shoulder abducted to 90 to 110° and horizontally adducted 15 to 20° or in the position of scaption,[9–11] elbow extension, forearm supination, wrist extension of 15 to 25° with neutral deviation, MCP joints in 60 to 70° flexion, interphalangeal (IP) joints in extension, thumb in palmar abduction, hip extension and abducted 20° (no external rotation), knee extension, and neutral ankle dorsiflexion.[8–10] There is no universal position, however, to prevent all contractures,[8] and burn depth and location must be considered when determining optimal anticontracture positioning. Positioning is also used for managing edema, facilitating functional alignment of joints, enabling wound care, and preventing peripheral neuropathies.[1] Positioning may be active, which is nonrestrictive and ideal for cooperative patients, or passive, which involves the use of restraints or splinting.[12] Positioning protocols must be monitored regularly for effectiveness and require cooperation of the entire burn team for successful implementation.

## SPLINTING

### *Indications*

Although splint use varies among burn rehabilitation professionals,[13–17] it is a common intervention used to prevent scar contractures.[1,14] Splints are used through all phases of burn rehabilitation[1,14–17] with indications being soft tissue or skin graft protection,

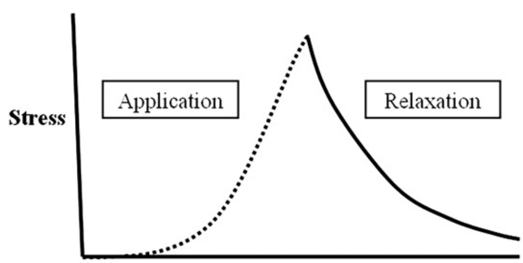


**Fig. 4.** Stress relaxation.

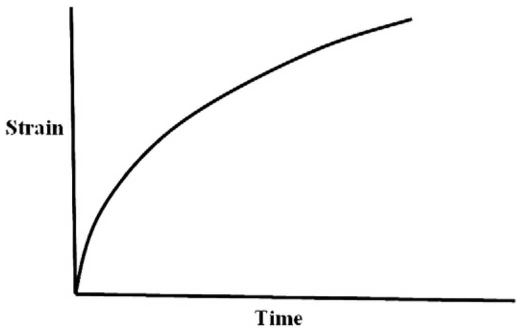


**Fig. 5.** Tissue creep.

antideformity positioning, tissue lengthening, or tissue length preservation.[1,18] Early implementation of splints is a key component of contracture management because of the influence on collagen orientation of developing fibers.[3,19,20] Burn scar contractures may be perceived as a late sequella of a burn; however, burn scar contractures begin with the process of wound closure and continue through scar maturation. Applying current statistical analysis, Huang and colleagues[21] and Bunchman II and colleagues[22] demonstrated a decreased contracture rate when using splints compared with not using splints (**Table 2**). Patients who wore splints for more than 6 months had less chance of developing a scar contracture than those who wore splints for a shorter period of time.[21,22] Additionally, a preliminary report showed that splinting interventions can reverse scar contractures more rapidly compared with routine interventions, including exercise, massage, and pressure in the long-term rehabilitation phase.[23]

### *Types*

There are 3 types of splints routinely used with burn patients: static splints, static progressive splints, and dynamic splints.[1] Static splints maintain a fixed position and are indicated for skin graft protection after surgery or anticontracture positioning if adequate ROM is not gained with exercise alone. Static splints can be serially modified to account for increased tissue length gained with exercise or extended positioning.[8] Static progressive splints or dynamic splints are indicated if sufficient ROM is not obtained with static positioning and exercise. Such splints may be implemented for correction of contractures. Static progressive splints provide inelastic stress to tissue at end range and allow adjustment to the stress as the tissue lengthens via stress relaxation.[1,24] Dynamic splints provide a continual stress to tissue over

**Table 2**
**Odds ratio describing contracture versus no contracture**

| Splint | Axilla | | Elbow | | Wrist | | Knee | | Neck[a] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Time | OR | *P* Value | OR | *P* Value | OR | *P* Value | OR | *P* Value | OR | *P* Value |
| <6 mo | 2.04 | 0.25 | 1.9 | 0.09 | 0.8 | 0.38 | 2.9 | 0.04 | 5.4 | <0.01 |
| 6–12 mo | 14.5 | <0.01 | 8.8 | <0.01 | 3.9 | <0.01 | 9.8 | <0.01 | | |
| >12 mo | 38.6 | <0.01 | 18.9 | <0.01 | 6.6 | <0.01 | 14.7 | <0.01 | | |

*Abbreviation:* OR, odds ratio.
[a] Specific time frame not stated.

time.[1,25] A hierarchical approach to splinting has been advocated that suggests the use of static progressive splinting for more restrictive tissue shortening and dynamic splinting for more responsive tissue deficits.[26] The use of well-designed static progressive or dynamic splints obviates remolding the basic form of the splint as is done with serial static splinting. Instead, the straps, slings, hinges, or other mobile forces can be modified as motion changes. A case study showed increased ROM when using a dynamic splint compared with a static splint.[25] Many splint designs have been described in the literature[27,28]; however, there are minimal studies comparing the effectiveness of these devices. Thus, prospective randomized comparative studies are needed to identify optimal splinting practices (**Fig. 6**).[1]

Dynamic and static progressive splints are both commercially available and can be custom fabricated. Advantages of custom-fabricated splints are that they can accommodate to a patient's unique size and profile and can be adjusted as edema fluctuates or bandage thickness changes. Disadvantages of custom-fabricated dynamic or static progressive splints are that they can be technically challenging and can be time consuming to fabricate. Some of the technical challenges pertain to the direction of pull on the involved body part(s). The angle of pull should be 90° to prevent friction and provide an optimal force.[29] Splint adjustments have to be made continuously to maintain this angle of pull as ROM gains are made. The force should remain a low-load force as previously indicated.

### *Principles*

Regardless of the splint type, some basic principles should be considered when fabricating and applying splints: (1) splint design should be simple; (2) wound depth and available ROM should be considered; (3) splint should accommodate skin recruitment throughout cutaneous functional units[6]; (4) instruction on splint indications, precautions, wearing schedule, and proper fit should be given to the patients and care providers; (5) splint fit should be re-evaluated regularly; (6) hands should be given special consideration due to the complex anatomic implications; (7) adequate time should be allotted for splint fabrication; and (8) an optimal splint wearing schedule should be monitored and modified based in patient response.[14]

#### *Splint design*

A device is only effective if fabricated and applied properly. Although complexity may be necessary with multiple joint involvement, ensuring that patients and/or care providers are able to properly apply a splint so the device can be worn without compromising its primary purpose is an important education piece. Generally speaking, static splints should be attempted before more complex dynamic or static progressive splinting.

**Fig. 6.** Static progressive splint.

### *Wound depth and ROM considerations*

Superficial partial-thickness burns typically do not require splinting due to the low contracture risk associated with rapid reepithelialization.[1] A splint is highly recommended for deep partial-thickness or full-thickness burns if patients are unable to achieve full active ROM, have impaired consciousness, or are noncompliant with their exercise program.[1] Splints should also be considered to immobilize joints where exposed tendons are present to protect these structures from rupture.

### *Splints and cutaneous functional units*

Fields of skin recruited during ROM must be considered when contemplating which joints should be included in a splint.[6] Although skin closest to the involved joint is of particular interest, skin is still recruited serially as ROM increases.[6] If ROM of a particular joint is more limited when an adjacent joint is moved into a position requiring greater tissue length, then both joints should be included in the splint. This places the involved tissue in a lengthened position to provide optimal tissue stress.

### *Splint instruction for patients and care providers*

Patients or care providers must have a good understanding of the purpose for a splint and a proper wearing schedule to facilitate compliance. Caregivers should be instructed in assessing proper splint fit, including skin inspection, to prevent the incidence of skin breakdown from excessive pressure. Providing verbal and written instructions is recommended. Additionally, labeling the splint and supplying photos of its proper fit may be helpful.

### *Regular re-evaluation of splint fit*

A splint's effectiveness is only as good as its fit. Burn patients commonly require varying thickness of bandages to cover their wounds under the areas being splinted. Bandage thickness can affect the position of the involved area and can alter optimal fit. As layers of bandage increase, a splint's design must be adjusted to fit correctly.[30] For example, the metacarpophalangeal (MCP) crease of a resting hand splint should be moved proximally as the hand dressing thickness increases.[30] In the later stages of burn rehabilitation, bandage thickness becomes less of an issue and, instead, poor fit can be caused by increased activity or the slick nature of pressure garment material.

As scar tissue lengthens and ROM gains are made, a splint needs to be adjusted to account for these changes. This may include remolding a static splint or changing the angle of pull on a static progressive or dynamic splint. The size of the splint may also have to be altered as changes in edema occur. Strap placement should be re-evaluated as changes in splint position or design are made. Straps provide strategic stabilization and are critical for optimal positioning of involved structures. For example, a forearm-based resting hand splint must have one strap over the dorsal wrist for wrist extension to facilitate tenodesis, one strap over the proximal phalanges to secure MCP flexion, and a third strap on the proximal forearm to stabilize the splint (**Fig. 7**).

### *Special hand consideration*

The hand is one of the most commonly affected sites for developing a burn scar contracture.[1,31–33] The hand is also the most frequently splinted body region after a burn.[16] The superficial nature of tendons and joints in the hand places burn patients at great risk for damage to these structures, causing deformities, such as claw hand deformity, boutonnière, or mallet deformity.[34] A review of a large adult sample of severe hand burns showed that 81% of patients had abnormal ROM if the burns involved the tendons or joints; however, almost 81% had normal or near-normal

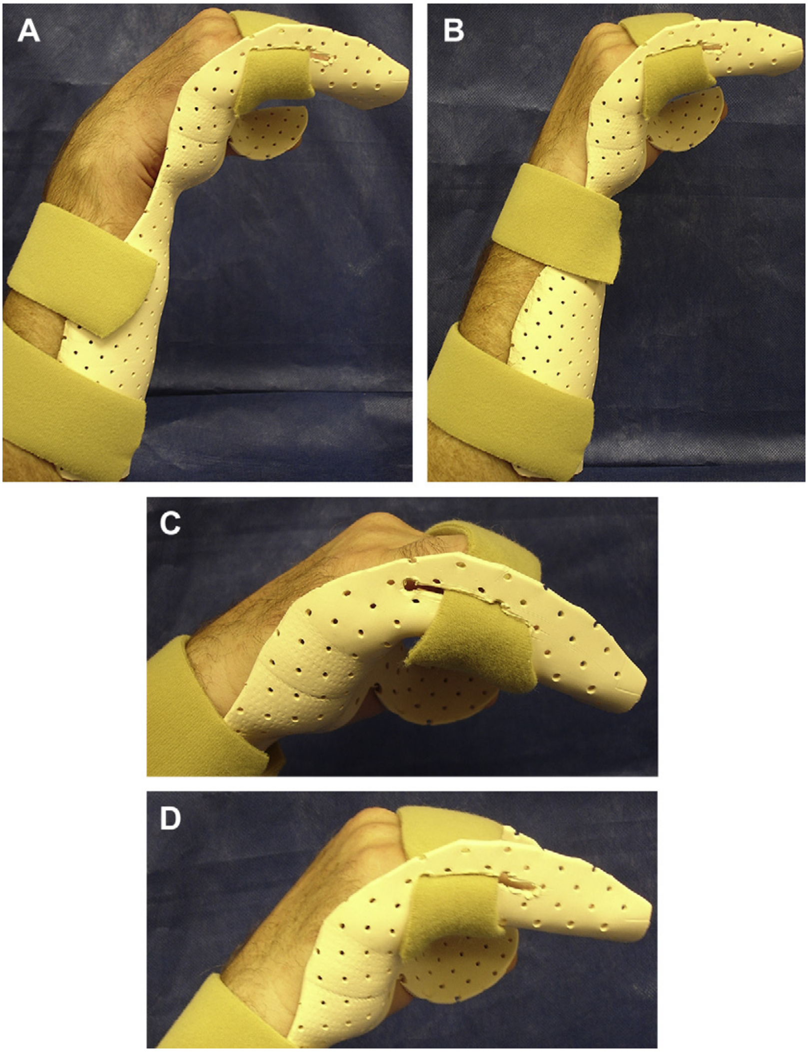


**Fig. 7.** Effect of strap placement on a resting hand splint. (*A*) Improper wrist strap placement resulting in wrist flexion. (*B*) Proper wrist strap placement providing relative wrist extension. (*C*) Improper digital strap placement facilitating proximal interphalangeal (PIP) flexion and MCP joint flexion. (*D*) Proper digital strap placement over proximal phalanx promoting MCP joint flexion and PIP joint extension.

ROM with deep partial-thickness or full-thickness burns that did not involve tendons or joints.[35] Thus, extreme care should be made with splinting or positioning to protect the soft tissue over joints after a deep partial-thickness or full-thickness burn or after skin grafting. The development of peripheral neuropathies that affect the hand can result in muscle imbalances that can potentially increase the risk of developing deformities as well. Deeply burned hands are commonly splinted in the intrinsic plus position[1] (MCP flexion and IP extension) acutely. This position places the collateral ligaments at the MCP joint in a lengthened or safe position and reduces the stress placed on the superficial tendons of the extensor mechanism over the IP joints. This position also places the hand in the antideformity position as dorsal hand edema promotes wrist flexion, MCP hyperextension, and IP flexion (**Fig. 8**).[36] Consideration must be given, however, to the impact that prolonged positioning in the intrinsic plus position has on contributing to tightness of the intrinsic musculature of the hand. The presence of tightness in these muscles can limit digital ROM and possibly lead to swan-neck deformities.[37] Clinicians should incorporate intrinsic elongation into a patient's exercise program if there are any signs of intrinsic muscle tightness. Palmar burns are routinely placed in finger extension and thumb radial abduction.[8] If both dorsal and palmar burns are present, the clinician must prioritize the desired position based on contracture risk.

#### *Splint fabrication time*

A recent study evaluating time demands of burn rehabilitation staff showed that splint fabrication was the most time-consuming task for staff compared with other components of treatment.[38] Splint fabrication is an integral component of burn rehabilitation demanding a significant amount of staff time and, therefore, this must be considered when developing a comprehensive care plan and determining staff ratios.[1]

#### *Splint wearing schedule*

The ideal splint wearing schedule has not yet been established.[14] The biomechanical model used in burn rehabilitation[5,39] suggests that the longer a splint is worn, the greater the chance for tissue lengthening. Some practitioners use a 2-hours-on, 2-hours-off wearing protocol[1,14] that may have resulted from a reference advocating such a schedule to prevent splint contamination[40] or from the common positioning schedule of turning patients every 2 hours for optimal pressure relief.[5,41] Some clinicians advocate performing active ROM during the day and splint wear only at night.[1,42] An animal study demonstrated that 6 hours of stress was needed to properly orient developing scar tissue.[20] Regular clinical evaluation of ROM and function is necessary to determine ideal splint wearing schedules for individual patients. Schedules should be determined and adjusted according to the observed changes in passive ROM and activity level.

### CASTING

An alternative to splint use is cast application. Cast fabrication is described elsewhere for both the adult and pediatric patient populations.[43–46] Casting has been used as an anticontracture device for the hand,[45–49] wrist,[47,50] elbow,[50,51] axilla,[52] knee,[50] and ankle[50,53] as well as for protection after skin grafting.[44] The reported frequency of cast change ranges from daily to every 10 days.[47,48,50–53] Casting works based on the biomechanic principle of stress relaxation in much the same way as does a static

**Fig. 8.** Edematous hand promotes antideformity position.

splint. One major advantage of casting patients compared with splinting is that a cast is unable to be removed easily. Clinicians need to provide adequate pressure relief over bony prominences, however, to prevent skin breakdown.

## BURN REHABILITATION PHASES

Burn rehabilitation is a continuum of care that consists of acute, intermediate, and long-term rehabilitation phases (see **Fig. 1**).[3] The acute phase begins at the time of admission and extends until 50% wound closure is achieved or skin grafting has begun.[3] The intermediate phase constitutes the time surrounding wound closure extending to complete wound closure.[3] The long-term phase starts at wound closure and continues to the period in which the patient has received maximal benefit from rehabilitation to include reconstructive surgery.[3] There is some overlap of these phases dependent on the stage of healing that is taking place for multiple wounds.[3] Clinical priorities change throughout this continuum, and, therefore, the goals of splinting and positioning shift for each phase.

### *Acute Rehabilitation Phase*

Managing edema associated with a burn is a primary rehabilitation goal during the first few days after a burn. Because edema generally peaks within 12 to 48 hours post burn,[8,54,55] it is important to initiate proper positioning on admission. The presence of edema can limit ROM, impair wound healing, and lead to vascular compromise.[8,54] Edema after a burn can affect all parts of the body, including nonburned tissue[55]; thus, elevation of any edematous area is paramount during the acute or resuscitation phase. Elevation is commonly used to facilitate edema reduction. Elevation of the extremities should include the hand or foot being placed above the elbow or knee, which should be at or above heart level.[8,9,56] Although elevation is the primary means of edema control during the acute phase, using a resting hand splint may help oppose the deforming force that edema places on the hand and wrist.[1] Caution is advised, however, with any splint used during the acute phase due to the risk of causing excessive external pressure leading to tissue ischemia.[1] Splint application with constrictive bandages is not recommended during the initial resuscitation phase. Appropriate positioning and splinting can also protect the healing wound, provide pressure relief, and help prevent contractures in the acute phase of rehabilitation.[8] Recent trends have demonstrated an increase in anticontracture positioning and an increased frequency of splint application with both deep partial-thickness burns and full-thickness burns on admission.[15,57]

In the acute rehabilitation phase, positioning and splinting are also used for pressure relief. Burn patients are at high risk for pressure sores due to the presence of multiple factors that can contribute to impaired skin integrity. These include, but are not limited to, open wounds with associated drainage, shear, friction, and potential for unrelieved pressure.[8,58] Areas highly susceptible to skin breakdown are the heels,[55] sacrum, ankles, wrists, elbows, and occipital area.[8] Some options for splinting and positioning devices can be found at burntherapist.com.[59]

### *Intermediate Rehabilitation Phase*

The intermediate rehabilitation phase begins with skin grafting and can include the wound contraction process for nongrafted wounds and ends at wound closure. Positioning and splinting priorities are aimed at protecting skin grafts and facilitating wound healing while maintaining tissue elongation. Managing edema may also still need to be addressed in this phase. Positioning and splinting can be used to prevent maceration of the superficial wound by elevating or suspending the donor site away from bed contact (**Fig. 9**).[60–62] Static splints are the primary type of splint used during the intermediate phase of rehabilitation due to the combined intent to protect skin grafts from shear while maintaining a position required for tissue elongation.

Immobilization after a split-thickness or full-thickness skin graft is a generally accepted practice for skin graft adherence. The use of splints to achieve immobilization is variable, however.[15,17,57] Some clinicians prefer not to splint over a fresh skin graft due to concerns that the splint may cause pressure or shear that may lead to graft failure. Engrav and colleagues[63] demonstrated that the application of splinting devices immediately after skin grafting did not damage grafts of the face and neck. Recent trends show that an increased number of therapists are applying splints after acute skin grafting and supports the notion that splint use for skin graft protection is gaining acceptance.[15,57] The period of immobilization after skin grafting and the method of immobilization vary among clinicians. The immobilization period after skin grafting typically lasts from 3 to 7 days.[1,8] Adequate immobilization can be accomplished by using prefabricated splints, negative pressure wound dressings,[1,8,64] or custom thermoplastic splints. The position of immobilization is dependent on the location of the graft and clinician preference. Surgeons and therapists should discuss desired position and duration of patient immobilization. Although skin graft adherence is the primary objective after skin grafting, the concept of adequate tissue length should also be considered during the procedure. Placing an excised area in a position that requires a greater amount of skin transfer may help reduce ROM loss after surgery due to contraction. Maintenance of this position during the immobilization phase also is beneficial. When possible, having a burn therapist present in the operating room during surgery to assist with adequate positioning is recommended, especially if a negative pressure wound dressing is used to provide immobilization for a hand.[1] A cases series[65] reported a reduced rate of axillary contractures with splint use after skin grafting; however, controlled prospective studies are needed to establish the effectiveness of splinting after skin grafting.[1]

### *Long-Term Rehabilitation Phase*

The long-term rehabilitation phase represents the longest duration of all of the phases. This stage of care spans from the time of wound closure to the point that a plateau is reached with rehabilitation.[3] The rehabilitation emphasis during this phase is to prevent, minimize, and/or correct contractures.[8] Because scar maturation occurs

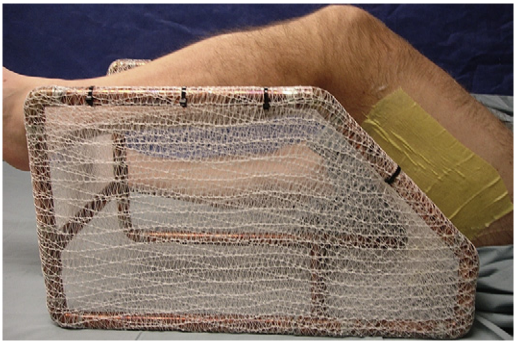

**Fig. 9.** Lower-extremity positioning device. (*From* Hedman TL, Chapman TT, Dewey WS, et al. Two simple leg net devices designed to protect lower-extremity skin grafts and donor sites and prevent decubitus ulcer. J Burn Care Res 2007;28(1):115–9; with permission.)

throughout this stage of recovery, ROM gains can be achieved with tissue lengthening using the principles of stress relaxation[23] or tissue creep.[8,66,67] Positioning devices and splints provide a means of delivering a desired low-load force for a long duration.[29] The combination of low-load force and long-duration hold provides the preferred stress for scar tissue lengthening. Prompt attention to lengthening scar tissue limits the likelihood that underlying joint capsular tightness or other soft tissue contracture will develop. Static splinting remains highly used during the long-term phase, both after reconstructive surgery and for increasing soft tissue length if an ROM deficit is noted.[15–17] Static progressive and dynamic splints are often used as corrective devices in this phase of recovery. Due to the extended duration of the long-term rehabilitation phase and associated scar maturation, it is common to alternate the use of static, static progressive, and dynamic splints as ROM and surgical needs change. For optimal outcome, the clinician must continue to reassess the effectiveness of a splinting and positioning program while making adjustments and progressions as needed throughout this rehabilitation phase.

## SPECIAL CONSIDERATIONS FOR CONTRACTURE MANAGEMENT IN CHILDREN

The basic principles of scar contracture management (discussed previously) apply to patients who have suffered a burn, regardless of their age. Techniques used to apply positioning and splinting principles, however, may be considerably different for children than adults. Children are dynamic human beings who progress through a series of predictable physical, cognitive, emotional, and psychosocial developmental stages.[68] A variety of factors related to a child's development can affect the success of positioning and splinting regimens aimed at preventing, minimizing, or correcting burn scar contracture. Often, young children have not developed the cognitive reasoning to fully comprehend the benefits of such interventions, which leads to increased anxiety and decreased cooperation. Furthermore, a child's small body size, increased activity level, and decreased attention span create challenges with fabrication, fit, and compliance of positioning and splinting devices. Children are physically and emotionally dependent on a larger family unit, so all treatments must incorporate parents, caregivers, or other family members for greatest success. The positioning and splinting goals (described previously) for each stage of burn rehabilitation apply to children as well but with special consideration given to the unique characteristics of developing children. This article describes strategies for improving the effectiveness of contracture management using positioning and splinting techniques specifically with children after burn injury.

### *Pediatric Positioning Strategies*

Developing an effective antideformity positioning program for a young child often proves challenging for a burn therapist. Traditional positioning devices, such as pillows, wedges, bolsters, and linens, which are used with adult patients, may be less effective when used with children due to their elevated activity level and lack of understanding of the importance of compliance. More body-encompassing positioning devices, such as slings and foam/gel positioning devices, may prove effective for positioning to relieve pressure or prevent contractures in the acute rehabilitation stage (**Fig. 10**). Such devices are versatile and accommodate a child's small size while facilitating any developmental needs.

As children gain mobility in the intermediate and long-term rehabilitation phases, positioning devices typically are more successful if the environment is concurrently managed to sustain a child's attention. Providing engaging, age-appropriate, and enjoyable activities improve a child's compliance and cooperation. For example, after contracture release of the anterior neck, when immobilization of the neck in an extended position is required, an inverted television has been used to allow school-aged children to engage in age-appropriate video game play or television viewing and improve cooperation with a prolonged positioning program.[69] Educating caregivers and parents on proper positioning and, when appropriate, involving them in routine monitoring of a child's position can improve overall compliance as well.

When possible, ROM should be maintained with active exercises, function, and play. Positioning programs should be used while a child is at rest. Active ROM has been shown to facilitate functional movement, have positive effects on conditioning, and reduce edema.[13] Active motion also capitalizes on children's natural motivation to move and interact with the environment versus restricting motion, which can increase anxiety or agitation in children. When immobilization is necessary to protect wounds or grafts or when ROM cannot be maintained with active exercises and positioning, however, then passive positioning and splinting devices become necessary.

**Fig. 10.** Pediatric positioning device.

### *Pediatric Splinting Strategies*

Splinting children is not just a matter of reducing the size of an adult splint and donning it. There are special considerations for children in almost every aspect of splint fabrication and use.

#### *Splint design*

Choosing the appropriate splint design for a child can be a learning process for a burn therapist. The splint chosen should appropriately fit the smaller limb segments of a child and still meet its intended goals. Dynamic splints, despite showing improvements in ROM in adults,[25] are used less often with small children because they contain small parts and protruding objects, both of which may be unsafe for children.[70] In addition, moveable parts are difficult to anchor to small levers and the cognition and responsibilities needed for proper fit of dynamic splints may be inappropriate for children's cognitive level or difficult for parents to continually monitor.[70] Alternatively, static and static progressive splints are used more often to provide a low-load, long-duration stress to scar tissue. Similar to adults, static splints should be fabricated after SLI and donned with the tissue at a safe maximal length to maintain passive ROM, then remolded or adjusted as changes in motion are achieved. With children, special care should be taken to keep the design simple and low profile and to avoid detachable parts or sharp edges. Pediatric splint designs should also consider other anatomic differences between children and adults, such as thinner, more fragile skin and joint hypermobility.[12]

#### *Splint fit*

Even the most perfectly designed splint is ineffective if it is not worn appropriately. As with adults, splints can easily shift, slip, or rotate on children due to fluctuating edema and variations in bandage thickness.[30] Splint fit in children can be further impaired by small appendages, increased activity level, and decreased cooperation. The small size of children's limbs (especially hands and feet) leaves therapists short levers with which to anchor a splint, often resulting in distal slippage or rotation of the splint. If not carefully monitored, this can lead to discomfort, skin breakdown, or exacerbation of a contracture position at a joint. To enhance proper fit, splints should be made with longer levers so that they can be anchored more effectively.[70] Care should be taken, however, to avoid making them so long that baby fat causes pinching with movement at the proximal joint.

Decreased surface area of a small splinted limb reduces the space available for appropriate strapping. Narrowing the straps to fit a splint to a small limb may not be an option in the acute stages of burn recovery due to shifting edema and the risk of constriction. An effective alternative is to use elastic compression bandages or self-adhesive circumferential wraps to encase the entire splint and distribute pressure evenly while securing the splint in place against slipping.[12] Children tend to be more active than adults, more resistant to splint application, and masters at self-removal of splints. By using a proper size self-adhesive circumferential wrap, a splint is better secured in place with movement and or attempts at removal. If a child persists with unwanted doffing of a splint, anti-Houdini options for anchoring splints should be considered.[70] Many splint designs have been established specifically for children with consideration for small body size and increased activity level.[71–74]

Younger children are not always able to fully communicate their needs and concerns regarding splint comfort. Therefore, monitoring the fit of a splint, especially after initial fabrication, is essential. Burn therapists should evaluate splint comfort and fit through careful observation of the child, regular examination of underlying tissue, periodic motor screening, and continual communication with nursing staff and caregivers. Splints should be well labeled and diagrams or photographs provided to nursing staff for proper application and monitoring. When appropriate, parents can be instructed on splint fit and skin inspection. Splints made for use in the intermediate and long-term phases of rehabilitation must continue to be evaluated regularly at follow-up visits and adjusted as necessary for growth or changes in available motion.

### *Fabrication*

Successful fabrication of splints for children with burn injury requires not only technical knowledge of splint mechanics and skilled manipulation of splinting materials but also artful engagement of children. To decrease children's anxiety and encourage cooperation, therapists should create a nonthreatening environment, prepare caregivers and children with information about the splint fabrication process, work efficiently, and mold properly on the first attempt. Creating a safe and comfortable physical environment in advance includes having needed equipment within therapist reach and keeping cords and hot pans out of reach of children and sharp instruments out of sight.[75] Introducing the splint material to children, allowing them to touch it, or fabricating a small splint on a doll or parent first, works to familiarize children with the splint fabrication process and reduce anxiety.[75,76]

Decreasing children's anxiety helps somewhat to keep them still during splint fabrication, but children's decreased attention span or increased pain or sensitivity requires that therapists work quickly and avoid multiple failed attempts.[75] Splint fabrication can be done in stages if there are greater time demands for complex splint designs or if the involved areas are sensitive or have limited accessibility. Patterns or photocopies taken of the limb segment can be made in advance to reduce anxiety-provoking treatments and improve patient tolerance. Therapists can use another time-saving technique when fabricating a splint by using the uninvolved extremity or an extremity of a similarly sized sibling to form part of the splint, reserving manipulation of precision areas for the affected side.

Selection of the proper materials for a given patient eases the process of fabrication. Thermoplastic materials used should have high memory, so they can be remolded as edema and bandage thickness changes, yet have stretch and conformability that allows for efficient and precise shaping as needed. Children are especially fearful of warm or hot material; therefore, it may be necessary to let the material cool longer than what is ideal for splint fabrication before placing the material onto a child. Splinting over a layer of stockinette can further reduce the amount of heat felt by a child.

A portion of children's willingness to wear a splint is dependent on their perception of the splint. Creating a visually appealing splint and involving a child in the creation process enhance a child's interest and acceptance of wearing a splint. Techniques for making splints more kid friendly are found in **Box 1**. If children show persistent noncompliance and are at risk for contracture development, then serial casting is a treatment option that has shown good outcome with children.[44,53]

### *Splint wearing schedule*

Although the ideal splint wearing schedule for burn patients has yet to be determined, therapists can evaluate the therapeutic benefit of the prescribed splint by monitoring changes in ROM. Decisions regarding frequency and duration of splint wear vary depending on patient needs and situation. In addition to assessment of ROM, pediatric burn therapists must consider children's developmental needs, activity level, motivation for movement and play, and scar characteristics when determining an optimal splint wearing schedule.

**Box 1**
**Techniques for making splints kid friendly**

- Use colored straps, wraps, and materials
- Allow children to decorate splint and straps with nontoxic colored markers
- Use rub-on tattoos, stickers, or shapes from thermoplastic scraps for decoration
- Round edges
- Avoid small or detachable parts
- Fabricate matching splint for a favorite doll or stuffed animal
- Name the splints to create positive personifications
- Liken the splint to a superhero's gadget or a princess' royal adornment

## SUMMARY

Whether a patient with burn injury is an adult or child, contracture management should be the primary focus of burn rehabilitation throughout the continuum of care. Positioning and splinting are crucial components of a comprehensive burn rehabilitation program that emphasizes contracture prevention. The emphasis of these devices throughout the phases of rehabilitation fluctuates to meet the changing needs of patients with burn injury. Early, effective, and consistent use of positioning devices and splints is recommended for successful management of burn scar contracture.

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